SUPPORT DOCUMENT FOR BART DETERMINATION FOR LAFARGE NORTH AMERICA, SEATTLE PLANT

July, 2008

Table of Contents

Executive Summary

The Best Available Retrofit Technology (BART) program is part of the larger effort under the federal Clean Air Act Amendments of 1977 to eliminate human-caused visibility impairment in all mandatory federal Class I areas. Sources that are required to comply with the BART requirements are those sources that

1. Fall within 26 specified industrial source categories;
2. Commenced operation or completed permitting between August 7, 1962 and August 7, 1977;
3. Have the potential to emit more than 250 tons per year of one or more visibility impairing compounds;
4. Cause or contribute to visibility impairment within at least one mandatory federal Class I area.

Lafarge North America (Lafarge) operates a portland cement plant in Seattle Washington. The cement production process results in the emissions of particulate matter (PM), sulfur dioxide (SO_2) and nitrogen oxides (NOx). All of these pollutants are visibility impairing.

Cement plants such as the Lafarge facility are one of the 26 listed source categories. The Lafarge plant began commercial operation in March of 1967 and has the potential to emit more than 250 tons per year of SO2, NOx and PM. 16 of the 18 processing areas at the plant are BART-eligible. Lafarge's major sources of visibility impairing pollutants are clinker cooling system and the wet process rotary cement kiln.

Modeling of visibility impairment was done following the Oregon/Idaho/Washington/EPA-Region 10 BART modeling protocol.[1] Modeled visibility impacts of baseline emissions show impacts on the 8th highest day in any year (the 98th percentile value) of greater than 0.5 deciviews (dv) at seven Class 1 areas. The highest impact was 3.16 dv on Olympic National Park. Modeling showed that NOx and SO_2 emissions from the kiln are responsible for the facility's visibility impact.

Lafarge prepared a BART technical analysis following Washington State's BART Guidance.[2]

The Department of Ecology (Ecology) determined that BART for PM emissions is the current system of baghouses and electrostatic precipitators at the facility. BART for NOx is selective non-catalytic reduction (SNCR). BART for SO_2 emissions from the kiln is the current level of control provided by the cement kiln process plus the addition of a dry sorbent injection system using lime. The BART controls selected by Ecology will result in a visibility improvement at Olympic National Park of approximately 1.1 deciview with improvements of 0.2 to 0.8 dv at other affected Class I areas.

---

[1] Modeling protocol available at http://www.deq.state.or.us/aq/haze/docs/bartprotocol.pdf
[2] "Best Available Retrofit Technology Determinations Under the Federal Regional Haze Rule," Washington State Department of Ecology, June 12, 2007

1. INTRODUCTION

This document is to support Ecology's determination of the Best Available Retrofit Technology (BART) for the Lafarge Cement plant (Lafarge) located in Seattle Washington.

The Lafarge plant produces portland cement using the wet process. 16 of the 18 emission units at the plant are subject to BART. The primary emission units of concern are the rotary kiln and the clinker cooler. The rotary kiln is the source of the SO_2 and NOx produced by the plant. The clinker cooler system is the largest particulate source. All other units are particulate sources controlled by baghouses with low individual emission rates resulting from low air flow rates and intermittent operations. These units collectively have the potential to emit less than 10% of the potential particulate emissions from the plant. Currently, particulate matter emissions from the kiln are controlled by an electrostatic precipitator. Particulate matter emissions from the clinker cooler are controlled by a baghouse and a back-up baghouse.

1.1. The BART Analysis Process

Lafarge and Ecology used the U.S. Environmental Protection Agency's (EPA's) BART guidelines contained in Appendix Y to 40 CFR Part 51, as annotated by Ecology, to determine BART for the kiln and clinker cooler. The BART analysis protocol reflects utilization of a five-step analysis to determine BART for SO_2, NO_X, and PM_{10}. The 5 steps are:

1. Identify all available retrofit control technologies;
2. Eliminate technically infeasible control technologies;
3. Evaluate the control effectiveness of remaining control technologies;
4. Evaluate impacts and document the results;
5. Evaluate visibility impacts

The BART guidance limits the types of control technologies that need to be evaluated in the BART process to available control technologies. Available control technologies are those which have been applied in practice in the industry. The state can consider additional control techniques beyond those that are 'available', but is not required to do so. This limitation to available control technologies contrasts to the Best Available Control Technology (BACT) process where innovative technologies and technologies and techniques that have been applied to similar flue gasses must be considered.

1.2. Basic Description of the Lafarge Plant

The Lafarge plant produces 465,000 tons of Portland cement clinker per year using the wet process. In this process the raw materials are fed into the rotary kiln as a slurry. In the kiln the slurry is heated to approximately 2700ºF so that the water in the slurry is evaporated and the ground material is converted to metal oxides, the active component of cement.

The primary minerals in portland cement are calcium oxide, aluminum oxides, iron oxides, and silica. These minerals are derived from limestone, sand, clay, iron ore, iron bearing byproducts, aluminum silicates, natural soils, petroleum contaminated soils, natural gravel, fly ash, boiler slag, lime, gypsum, fluid catalytic cracking unit catalyst, and Vactor wastes (street grit removed from storm drains and pipes), blast furnace and foundry sands, and other material containing calcium, silica, iron, and alumna.

The heat input to the kiln is limited to 282 MMBtu/hr by regulatory order[3]. Fuels which are currently permitted to be used in the rotary kiln are petroleum coke, coal, natural gas, tire derived fuel (TDF), waste oil, and tank bottom oil (TBO).

The raw materials are crushed, mixed with water to form a slurry, and pumped into the kiln. In the rotary kiln, heat from combustion is used to dry the slurry and calcine the clinker to remove the carbon dioxide and sulfur dioxide from the minerals to produce cement clinker. The clinker is quickly cooled prior to being pulverized into cement powder. Clinker cooling produces some particulates which are vented to a baghouse. The final cement powder is mixed with a variety of other materials such as gypsum to produce cements with specific properties.

The principle air pollution control authority for this facility is the Puget Sound Clean Air Agency (PSCAA).

1.3. BART Eligible Units at Lafarge

16 of the 18 emission units at the Lafarge plant are BART eligible. This means that these 16 emission units have the collective potential to emit more than 250 tons per year of SO_2, NOx, and PM/PM10 and they all commenced operation within the 15 year BART period[4]. Specifically, the plant was constructed during 1966 and is reported to have begun commercial operation in March of 1967.

Table 1-1 gives an overview of the potential emissions from the facility and identifies the primary BART eligible units. The Potential to Emit is based on permitted emission rates for the BART eligible units as listed in the Air Operating Permit issued to Lafarge and the supporting documents for the permit.

[3] PSCAA Order No. 6202
[4] The 15 year period ending with August 7, 1977, the date of passage of the Clean Air Act amendments of 1977.

Table 1-1 Potential to emit by emissions units and whether a BART analysis was performed by Lafarge

Emission Unit	Potential to Emit			BART Analysis Performed? (Yes or No)
	NOx	SO_2	PM_{10}	
Rotary, Wet Process Cement Kiln	1720	1650	71	Yes
Clinker cooler Primary and back-up baghouses	NA	NA	2816[5]	Yes
Raw Material, finished product storage bins, finish mill conveying system, bagging system, bulk loading/unloading system baghouses	NA	NA	480	No

Ecology reviewed the current controls for all emission units at the plant. Lafarge's review focused on the largest emitting units, the wet process kiln and the primary and back up clinker cooler baghouses. The primary clinker cooler baghouses are designed to operate all the time, while the back-up baghouses are intended to operate in the event of failure of one or more of the primary baghouses.

The rotary kiln is the stationary combustion source at the plant. Its emissions of NOx and SO2 have been periodically evaluated as part of permitting projects to add new fuels to the list of fuels approved for use in this rotary kiln.

The remaining BART eligible emission units at the facility are sources of particulate. These units are devoted to handling raw materials, intermediate materials (such as crushed rock or partially crushed clinker), or finished cement. PSCAA has previously subjected these units to a RACT analysis as part of bringing the Duwamish Industrial area into attainment with the PM_{10} ambient standards. The RACT analysis for these particulate sources imposed a PM_{10} emission limit of 0.005 g/dscf on all the BART eligible units. The clinker cooler primary baghouse is the exception to this PM_{10} emission limit.

1.4. Visibility Impact of BART Eligible Units at Lafarge Plant

Class I area visibility impairment and improvement modeling was performed by Lafarge using the BART modeling protocol developed by Oregon, Idaho, Washington, and EPA Region 10[6]. This protocol uses 3 years of metrological information to evaluate visibility impacts. As directed in the protocol, Lafarge used the highest 24 hour emission rates that occurred in the 3 year period to model its impacts on Class I areas. The modeling indicates that the emissions from this plant causes visibility impairment on the 8th highest day in any one year and the 22nd highest day over

[5] Primary baghouse system. The Back-up baghouse system is smaller than the primary system but could emit 1408 tons per year if it were to operate for a full year.
[6] A copy of the modeling protocol is available at http://www.deq.state.or.us/aq/haze/docs/bartprotocol.pdf

the three years that were modeled [7]. For more information on visibility impacts of this facility, see Section 3 below.

[7] A source causes visibility impairment if its modeled visibility impact is above 1 deciview, and contributes to visibility impairment if its modeled visibility impact is above 0.5 deciview.

2. BART TECHNOLOGY ANALYSIS

The Lafarge BART technology analysis was based on the five step process defined in BART guidance and listed in Section 1.1 of this report.

2.1. Clinker Cooler

Emissions from the clinker cooler are particulates formed during the cooling of the hot clinker and initial handling of the brittle clinkers in the clinker cooler. The existing clinker cooler baghouses and back-up baghouses were upgraded in 1994. RACT emission limits were established for these units by PSCAA in order for the area around the plant to return to compliance with the PM_{10} ambient air quality standard. The RACT emission limit for the primary clinker cooler baghouses is 0.025 grain/dry standard cubic foot (g/dscf). For the backup clinker cooler baghouses and all other baghouses at the facility the emission limitation is 0.005 g/dscf[8]

2.1.1 PM/PM_{10}

There are many PM/PM10 emission controls available for use at this facility. Only those that are capable of meeting the existing emission limitation on the units were evaluated by Lafarge. Controls for particulate emissions from the clinker cooler that were evaluated are given in Table 2-1

Table 2-1 PM /PM 10 Controls Evaluated

Control	Removal efficiency, % removal	Typical Emission limitation, grains/dry standard cubic foot (g/dscf)
Baghouse	99.8 – 99.9	0.004 – 0.2
Electrostatic precipitator	99.7	0.004 – 0.2

The existing baghouses provide for 99.8% control of particulate. This is equal or superior to an electrostatic precipitator. Other controls such as wet scrubbers and wet venture scrubbers are available but do not control PM emissions control as well as the currently installed baghouses.

2.1.2 Proposed BART

The currently installed baghouses are the highest level of particulate control available for the clinker cooler system. Lafarge has proposed that the existing baghouses are BART for particulate matter from this clinker cooling processing area.

2.2. Wet Process Rotary Kiln

This unit is a source of sulfur dioxide resulting form the combustion of sulfur containing fuels like coal and petroleum coke and from calcining sulfur minerals in the raw materials, forming

[8] PSCAA Order 5627

SO_2. NOx is formed in the combustion process through either oxidation of fuel bound nitrogen or oxidation of nitrogen gas in the high temperature flame zone of the kiln (prompt NOx). Particulates are formed in the dryer sections of the kiln through the rotary action of the kiln causing the brittle clinker to fall and fracture, forming smaller clinkers and dust.

2.2.1 SO_2 Control

Currently there is no specific SO_2 control installed on the Lafarge facility. The alkaline nature of the cement clinker formed in the kiln ensures that a considerable amount of sulfur dioxide control is provided by the process alone. EPA has evaluated this and reports that between 70 and 95% SO_2 control is provided by the cement clinker itself[9]. In-spite of this much 'native' SO_2 removal in the cement process, Lafarge evaluated the efficacy of a number of add-on SO_2 control technologies that could be applied to their facility.

Table 2-2 SO_2 Control Technologies Evaluated

Control technology	Control efficiency
Dry sorbent injection with lime or sodium	25 – 35% with an ESP, up to 50% with baghouse
Spray dryer (semi-dry FGD)	Up to 90% with baghouse, up to 70% with ESP
Wet limestone forced oxidation	Up to 95%,
Wet lime	Up to 95%
Ammonia forced oxidation	Up to 95%
Alternative fuels and raw materials	< 25%

Dry sorbent injection involves injecting a dry powder such as sodium carbonate or bicarbonate, calcium oxide, magnesium hydroxide, or calcium hydroxide. The dry reagent reacts with the SO_2 and any SO_3 in the flue gas to convert the carbonates, oxides or hydroxides to sulfites and sulfates. Injected sorbent (unreacted and reacted) is removed from the flue gas by the particulate control device. Due to the nature of the reaction between lime and the SO_2 in the flue gas, higher SO_2 removal rates and lower lime injection rates can be achieved with the use of a baghouse compared to the use of an ESP. The cost to replace the existing ESPs with a new baghouse was not evaluated, by Lafarge. The addition of duct sorbent injection to cement kiln exhaust is a relatively new concept in the industry, but has been used at a number of kilns around the world.

Lafarge has determined that dry sorbent injection using lime to control SO_2 from the kiln is technically available and analyzed the cost and other environmental impacts of its use at their facility. Their analysis indicates that there is:

- An appropriate location for injection of the dry sorbent,
- Recovered reacted dry sorbent can be beneficially utilized in the cement product,
- This location provides adequate contact time between the flue gas and the dry sorbent to provide a level of emissions control,

[9] AP-42 fifth Edition – compilation of Air Pollutant Emission Factors; Chapter 11.6 – Portland Cement Manufacturing, U. S. EPA, OAQPS,

- No new ductwork , reactor vessels, or replacement particulate control device is required, and
- That this location in conjunction with the existing ESPs will provide a SO_2 removal rate 25% (based on a design 7.5 % control effectiveness and a 90% availability of the control system) of the SO_2 leaving the kiln.

A **spray dryer** injects a slurry of recycled solids from the particulate control mixed with lime limestone, or sodium carbonate into the flue gases to react with SO_2 and SO_3 within the droplets containing the reagent chemical. The reaction rate slows as the droplets dry out. The reagent may be sprayed into a duct or a special reactor vessel. The dried reagent is commonly collected in a baghouse located downstream of the injection site, though there are boiler installations using an ESP. The presence of a baghouse increases the removal efficiency of the technique compared to use of an ESP.

Lafarge has proposed that installation of a spray dryer system is technically infeasible at this time. Use of this control would require the addition of:

- A new reactor tank since duct length provides insufficient detention time for the spray dryer process,
- Significant modifications to the existing ductwork at the exit of the kiln,
- Disposal costs for the sulfite waste product, and
- Higher removal rates than the duct sorbent injection process would require replacement of the ESPs with a baghouse.

Wet Scrubbers for SO_2 control come in a variety of configurations differing most importantly in the chemistry used. Lafarge evaluated the use of a wet limestone forced oxidation and a wet lime scrubbing systems. Ecology requested an evaluation of the use of an ammonia forced oxidation scrubber which is discussed below.

In a **wet limestone forced oxidation** scrubber, limestone is pulverized and mixed into a slurry which is injected into a reactor vessel. The SO_2 reacts with the limestone slurry to form calcium sulfite. The calcium sulfite in solution is mixed with air to force the reaction of the calcium sulfite to the calcium sulfate (gypsum) form. The calcium sulfate is removed from the scrubbing liquor via a belt or filter press. Lafarge would use the resulting gypsum by mixing it with the cement clinker produced by the kiln.

The plant already uses limestone as one of its major raw materials. Due to this use, the wet limestone forced oxidation process would not require additional or new raw material storage or handling equipment. The gypsum produced would offset purchased gypsum currently used by the plant.

In industrial boiler and coal fired electric utility boiler applications, the wet limestone forced oxidation process has demonstrated removal efficiencies of over 95%. There is limited application of this process to cement kilns. At a Lafarge facility in Europe, the process has been able to routinely achieve 81% control.[10]

---

[10] RTP Environmental Associates, **PROPOSED BEST AVAILABLE RETROFIT TECHNOLOGY (BART) FOR THE LAFARGE PLANT IN SEATTLE WASHINGTON,** December 2007, Page 3-6

Lafarge has determined that installation of a wet limestone forced oxidation scrubbing system is a feasible control option for this facility. The wet scrubber system would be located between the existing ESPs and the stack. At this location it would provide about 90 % removal efficiency. Lafarge estimates that such a system would only be available for 90% of the operating time for an annual SO_2 removal efficiency of 81%. Experience with this technology on coal fired power plants indicates that the availability of the control system will be much higher than 90%.

The **ammonia forced oxidation** process has been used on a few industrial and coal fired boilers, but not on cement kilns. The process is similar to the wet limestone process with ammonia replacing the calcium carbonate of the limestone and the final product being ammonium sulfate. The ammonium sulfate can be sold as a fertilizer.

In Lafarge's evaluation of this technology, they focused on the additional space necessary for ammonia storage, the incompatibility of ammonia with the cement product, and the perceived difficulty of selling the resulting ammonium sulfate.

While this technology provides essentially identical emissions control as the wet limestone forced oxidation process, Lafarge has determined the technology is not technically feasible for their facility.

Wet lime scrubbing is similar to the wet limestone forced oxidation process with a few notable differences. First instead of limestone (calcium carbonate) being used as the reagent, lime (calcium oxide) is used. Second, the wet lime process does not normally take the calcium sulfite formed and further oxidize it to calcium sulfate. Lime is considerably more expensive than limestone and without the inclusion of forced oxidation, the scrubber wastes (primarily calcium sulfite) must be landfilled. Lafarge did not propose to include the forced oxidation step.

Lafarge considers this process to be technically feasible to implement at their facility.

Cost analysis of the available SO_2 control options

Lafarge estimated the costs of the various control options that are considered to be technically feasible. The costs and emission reduction provided by each control option evaluated is in Table 2-3. Note, that Lafarge did not provide a cost analysis for dry sorbent injection that included the costs of O&M or lime. The cost effectiveness value shown in the table is solely for the capital cost.

Table 2-3 Cost and Cost Effectiveness Analysis Summary

Control option	Capital cost	Annualized cost	Current emissions, tons/year	Tons per year reduced, tons/year	Cost effectiveness, $/ton reduced
Dry sorbent injection	$6,090,000	$574,896[11]	570	142.5	$4,034[11]
Wet limestone forced oxidation	$77,064,944	$15,198,999[12]	570	462	$32,920
Wet lime scrubbing	Not calculated		570	399	

2.2.2 NOx Control

Currently the NOx emissions on the rotary kiln are controlled via combustion controls only. This provides a minimal amount of control, and is included in the baseline emissions condition. A number of controls were evaluated. Specifically;

Table 2-4 NOx Controls Evaluated

Control technology	Control Efficiency	Technically feasible?
Low NOx burners/indirect firing	15% reduction	Yes
Mid-kiln firing of whole tires	40% reduction	Yes
SCR	Up to 95% reduction	No
SNCR	30 - 40% reduction	Yes
Low NOx burners/indirect firing/SNCR	45 - 85% reduction	Yes
Low NOx burners/indirect firing/mid-kiln firing	55% reduction	Yes

Low NOx burners are a common control technique applied to many different combustion sources. Low NOx burners reduce the emissions of NOx by reducing the peak temperature of the flame area of the burner. Low NOx burners have been retrofitted on other wet process kilns in the US. According to Lafarge, the use of low NOx burners would require the replacement of the existing direct firing burner system (the burner fires directly into the rotary kiln) with an indirect firing system (where the burner fires into a smaller primary combustion chamber prior to being ducted to the kiln). The indirect firing component allows better control of the combustion conditions that lead to the formation of NOx. Lafarge determined that even though the conversion to an indirect firing system with low NOx burners may be a challenging construction project, the conversion is a technically feasible emission control option. The only significant adverse impact that they identified to this process was that it could result in a limitation on the volatility of the coals used. The systems are apparently adversely impacted when high volatility

[11] Does not include annual O & M costs. Based on 7% interest rate and 20 year equipment lifetime.
[12] Based on 7% interest rate and 20 year equipment lifetime.

coals are used. Sub-bituminous coals from the Wyoming/Montana Powder River Basin are considered to be high volatility coals.

Low NOx burners are estimated to reduce NOx emissions by about 15%. This technology is compatible with mid-kiln firing, SCR, and SNCR since it is implemented at the fuel feed end of the kiln. Lafarge has estimated that installation of Low NOx burners and indirect firing would have a capital cost of $15,000,000, and a cost effectiveness of $19,246/ton NOx reduced[13].

Mid-kiln firing is a process where a small part of the fuel needs to the kiln are introduced at approximately the middle of the kiln's total length. The process is also known as 'reburning' when applied to fossil fuel fired boiler systems. Whole tires are an attractive, available and relatively low cost fuel that has been proven in practice to reduce NOx emissions from long wet kilns such as this one. This technology is expected to reduce NOx emissions by about 40%[14].

While the literature indicates that any fuel can be added at this point, Lafarge indicates that a quick burning fuel such as wood chips or natural gas would not be effective at reducing NOx. Preferably the fuel used would have a relatively long burning time. Whole vehicle tires are the common fuel to meet this criteria, though dewatered wastewater sludge (biosolids) would meet this criterion. Lafarge considers this technology to be technically infeasible since they do not believe they can guarantee a long-term supply of whole tires. Lafarge currently has the capability to feed whole tires at the mid-kiln location, and did not estimate the cost of this control technique as part of this evaluation.

Selective Catalytic R**eduction** (**SCR**) is a NOx control technology that is commonly applied to combustion sources in both new construction and retrofit installations. It involves the use of a base or precious metal catalyst and the injection of ammonia or urea into the flue gas stream. The ammonia reacts with the NOx to form nitrogen gas and water. Some excess ammonia escapes the process and is emitted. World wide, there are only 2 reported uses of SCR on a cement kiln, and neither of these was on a wet process kiln. The Solnhofen cement plant is a preheater (dry process) type kiln and the SCR process is reported by the cement industry to have operated for a limited period of time before being shutdown. The other installation is on a dry kiln at Cementeria de Monselice in Italy is still in operation at this time. Dry cement kilns and wet process kilns differ in how and were the fuel is combusted. This difference is significant enough to remove SCR from consideration as an available emission control technology for a wet process kiln.

Selective Noncatalytic Reduction (SNCR) is a NOx control technology often used where lower rates of NOx reduction are required or SCR is not feasible. In SNCR process, ammonia, an ammonia water solution, or a urea water solution is sprayed into the combustion zone at a location where the temperature is in the range of 1600 – 1800ºF. At the Lafarge plant, this temperature window occurs at the same location where mid-kiln firing might occur. According to the company, mid-kiln firing and SNCR are incompatible technologies due to the location of

---

[13] The cost effectiveness is based on a 10% interest and a 15 year capital recovery period. Using the Ecology standard of 7% interest rate and a 20 year period changes the cost effectiveness to $2,921/ton reduced.
[14] Texas Cement Kiln Report (FINAL – 7/14/2006), page 4-42

this temperature window[15]. To date, there are 2 wet kiln plants operating with SNCR, one is the Ash Grove Cement plant in Midlothian Texas, the other facility is in Europe. When used on boilers, SNCR has exhibited a range of control efficiency from 30 – 70%. The higher levels of control effectiveness have not been demonstrated at the few wet process cement kilns using this control. Lafarge estimates that implementation of SNCR on their wet kiln would result in a reduction of NOx of 40%. They consider the process to be technically feasible.

Low NOx burners with indirect firing and SNCR can feasibly be combined at this facility. Lafarge has noted that implementation of low NOx burners/indirect firing and SNCR would increase the NOx control efficiency to 55%. Lafarge considers that the combination is technically feasible to implement, though they did not estimate the costs to implement this process.

Table 2-5 is a summary of the cost analysis and emissions reduction anticipated from use of the control technologies evaluated for NOx control.

Table 2-5 Costs and Cost Effectiveness Analysis Summary

Control option	Annualized cost	Uncontrolled emissions, tons/year	Tons per year reduced, tons/year	Cost effectiveness, $/ton reduced
Low NOx Burners/Indirect Firing	$2,738,547	2172.5	325.9	$19,246
SNCR	Not Calculated	2172.5	869	
Mid-kiln firing	Not Calculated	2172.5	869	

2.2.3 PM/PM_{10} Control

Currently particulate control on the rotary kiln is provided by parallel electrostatic precipitators. The plant design anticipated building a second rotary kiln and included as part of the initial construction one electrostatic precipitator for each kiln. Since only one kiln has been constructed, both precipitators are used on the one kiln. Each of the 2 ESP was sized to control emissions from one rotary kiln. Each ESP has 3 stages designed to handle an exhaust flow rate of 400,000 actual cubic feet per minute (acfm) with a space velocity of 5 feet/second. The one existing kiln operates with an exhaust flow rate under 200,000 acfm. Lafarge has ducted their 2 ESPs to their one kiln. As a result, each existing ESP has a space velocity of about 2 feet/second. As a result of the low velocities through the ESPs, actual removal efficiency is 99.95% or higher, which is equal to or exceeds the capability of a baghouse. The current emission limitation for the kiln/ESP stack is 0.05 g/dscf as required by PSCAA regulation[16].

[15] RTP Environmental Associates, **PROPOSED BEST AVAILABLE RETROFIT TECHNOLOGY (BART) FOR THE LAFARGE PLANT IN SEATTLE WASHINGTON,** December 2007, Pages 3-12 to 3-14 and letter of March 11, 2008
[16] Regulation I, Section 9.09

Lafarge proposes that the existing ESP system is BART for their cement kiln.

Lafarge's analysis of the visibility impact modeling indicates that the PM_{10} emissions do not contribute a significant amount to the plant's modeled visibility impact.

2.2.3 Proposed BART

Lafarge has proposed that the controls listed in Table 2-6 be determined to be BART for the rotary kiln.

Table 2-6 Lafarge's Proposed BART Controls

Parameter	Control technology	Proposed BART control efficiency, % reduction	Baseline 30 day average emissions	Proposed 30 day average emission limit
SO_2	Duct sorbent injection with lime	25	5.74 ton/day	4.31 ton/day
NOx	SNCR	40	19.1 ton/day	11.5 ton/day
$PM/PM_{10}/PM_{2.5}$	Existing ESP system	0	0.05 g/dscf	0.05 g/dscf

3. VISIBILITY IMPACTS AND DEGREE OF IMPROVEMENT

Lafarge modeled their current visibility impairment and the potential improvement from the 2 control scenarios that they evaluated as potential BART controls for their facility. In modeling the emissions, they followed the BART modeling guidance prepared for use by sources in Washington, Oregon, and Idaho. In accordance with the EPA BART guidance, this modeling protocol utilizes the CALPUFF modeling system and the 'old' IMPROVE equation to convert modeled concentrations to visual impairment. This approach is consistent with most of the states included in the Western Regional Air Partnership for modeling individual source visibility impairment. The 'old' IMPROVE equation is used because it is included within the CALPUFF modeling system and is part of the EPA accepted version of the model per 40 CFR Part 51, Appendix W. A new equation is available, but is not included within the version of the CALPUFF modeling system specified in the modeling protocol.

The results of the Lafarge modeling are shown in Table 3-1 for all Class I areas within 300 km of the plant plus the Columbia River Gorge National Scenic Area. The table shows the maximum day impairment due to Lafarge, the highest of the 3, 98^{th} percentile days of each year modeled, and the 98^{th} percentile day of all 3 years modeled. Also shown is the modeled visibility impairment resulting from the 2 control scenarios modeled by Lafarge. The modeled emissions for the baseline condition and the 2 control scenarios are included in Table 3-1. The shaded areas indicate values above the 0.5 dv threshold used to determine if a source contributes to visibility impairment.

The emission rates modeled were derived from operating records of the rotary kiln and reflect the highest 24 hour emission rate within the 3 years that were modeled. The emission reduction percentages (see table above) were applied to this maximum 24 hour emission rate and those rates were then used for modeling the visibility impairment/improvement that could be achieved through the use of the proposed controls. The maximum day SO_2 emissions during the 3 years of modeling were not used as that day was reported to be in an abnormal, upset operating condition. In reviewing the emission information, it is also unusually high compared to all other monitored days in the 3 year period. The modeled emission rates are shown in Table 3-1.

Ecology modelers have reviewed the modeling performed by Lafarge and have found that the modeling complies with the Modeling Protocol and produces a reasonable result.

The modeled emission reductions result in substantial reduction in the visibility impairment caused by Lafarge in all Class I areas modeled and in the Columbia River Gorge NSA. At the 3 most heavily impacted Class I areas, Olympic National Park, Mt. Rainier National Park, and the Alpine Lakes Wilderness, Lafarge's proposed BART controls would provide 0.8 to 1 dv reduction in visibility impairment in each of these areas.

Table 3-1 3-Year Delta Deciview Ranking Summary

Class I Area	Visibility Criterion	Baseline Emissions	Control Scenario 1: SNCR & DAA	Control Scenario 2: SNCR & Wet Scrubbing
Alpine Lakes Wilderness	Max delta deciview	4.93	3.342	2.779
	Max 98% value (8th high)	2.07	1.335	1.232
	3-yrs Combined 98% value (22nd high)	2.06	1.318	1.182
Glacier Peak Wilderness	Max delta deciview	3.34	2.234	1.754
	Max 98% value (8th high)	1.62	1.05	0.866
	3-yrs Combined 98% value (22nd high)	1.43	0.901	0.769
Goat Rocks Wilderness	Max delta deciview	1.56	0.979	0.859
	Max 98% value (8th high)	0.92	0.581	0.457
	3-yrs Combined 98% value (22nd high)	0.85	0.529	0.448
Mt. Adams Wilderness	Max delta deciview	1.49	0.934	0.812
	Max 98% value (8th high)	0.78	0.491	0.389
	3-yrs Combined 98% value (22nd high)	0.76	0.48	0.389
Mt. Hood Wilderness	Max delta deciview	1.72	1.097	0.874
	Max 98% value (8th high)	0.65	0.412	0.339
	3-yrs Combined 98% value (22nd high)	0.62	0.383	0.307
Mt. Rainier National Park	Max delta deciview	4.47	2.98	2.631
	Max 98% value (8th high)	2.04	1.261	1.092
	3-yrs Combined 98% value (22nd high)	1.78	1.131	0.959
North Cascades National Park	Max delta deciview	2.76	1.8	1.577
	Max 98% value (8th high)	1.48	0.947	0.754
	3-yrs Combined 98% value (22nd high)	1.27	0.798	0.693
Olympic National Park	Max delta deciview	6.99	4.893	4.25
	Max 98% value (8th high)	3.16	2.072	1.81
	3-yrs Combined 98% value (22nd high)	2.96	1.937	1.678
Pasayten Wilderness	Max delta deciview	1.37	0.876	0.736
	Max 98% value (8th high)	0.82	0.513	0.429
	3-yrs Combined 98% value (22nd high)	0.72	0.461	0.393
Class II area modeled per the Modeling Protocol				
Columbia River Gorge National Scenic Area	Max delta deciview	1.41	0.881	0.758
	Max 98% value (8th high)	0.59	0.371	0.336
	3-yrs Combined 98% value (22nd high)	0.51	0.316	0.265
Modeled Rates (lb/hr)				
	NOx -->	1595	957	957
	SO_2 -->	479	359	48
Modeled Rates (ton/day)				
	NOx -->	19.1	11.5	11.5
	SO_2 -->	5.7	4.3	0.6

The 8th day in any year or the 22nd day over the 2 year period, are the 98th percentile days.

4. ECOLOGY'S BART DETERMINATION

Ecology has reviewed the information submitted by Lafarge. In all but one case we agree with Lafarge's proposed BART technology evaluation. While the other particulate sources at the plant that are BART eligible were not evaluated, we note that the particulate emission limit on these units is based on the use of baghouses meeting an emission limitation of 0.005 g/dscf.

Ecology does not agree with Lafarge's proposed BART technology or emission limitation for NOx emissions from the rotary kiln.

4.1. Clinker Cooler Baghouses

These units are already well controlled with baghouses. Only an ESP could provide an equivalent level of control, and this would require removal and replacement of the existing baghouses, increase the electrical needs of the facility, and not produce a reduction in emissions. The current emission limitations on the clinker cooler baghouses are reflective of current BACT levels of control imposed on dry material handling equipment.

BART for the clinker cooler baghouses is the existing primary and backup baghouses and the emission limitations for these units contained in Regulation 1, Section 9.09 (in effect on June 30, 2008) and Order of Approval Number 5627. The emission limitations reflecting BART is provided in Table 4-1 below.

4.2. Wet Process Rotary Kiln

4.2.1 SO_2 Control

We performed additional cost and technology evaluations for SO_2 controls available for the facility. Those evaluations were specifically oriented to the use of a lime spray dryer or dry sorbent injection. Lafarge has proposed dry sorbent injection as BART for SO_2 control, but did not provided any cost information in their original analysis. At our request, they have supplemented that information and reported the capital cost of a dry sorbent injection system if $6,090,000. We have used this capital cost and estimated its annual operating costs to determine the cost effectiveness of this control. We estimate the annual costs of this control to be $1,116,571, for a cost effectiveness of $7,123/ton SO_2 removed. This is comparable to the applicant's estimated cost of $4,034, which does not include O&M and reagent costs.

The average cost effectiveness of this control is relatively high compared to other cost effective determinations by Ecology and other agencies. However the visibility improvement resulting from the implementation of this control technology is substantial. Using the impacts on Olympic National Park, as an example, indicates that on the days where Lafarge has its highest adverse visibility impact, the SO_2 emissions account for approximately 20% of the total visibility impairment. On the worst 98th percentile day in 2004 of 2.072 dv, this indicates that approximately 0.8 dv is due entirely to the SO_2 emissions from the plant. We believe that this is a significant visibility improvement that comes at a reasonable cost of $1.4 million/dv.

Ecology determines that BART for SO_2 at the Lafarge plant is the current level of SO_2 control afforded by the cement process plus addition of a duct sorbent injection system using lime with an additional removal effectiveness of 25%. Emission limitations resulting from use of this technology are shown in Table 4-1 below.

4.2.2 NOx Control

In response to our review comments, Lafarge evaluated the inclusion of low NOx burners at their facility. As noted by Lafarge, low NOx burner technology is compatible with both SNCR and mid-kiln firing of whole tires, additional technologies that are technically feasible and provide approximately the same level of NOx control in long wet kilns. The cost effectiveness of SNCR with a 40% removal rate is estimated by Ecology to be $1,409/ton reduced[17]. The cost effectiveness of SNCR plus low NOx burners is estimated to be $6,274/ton[18] reduced. The incremental cost of adding low NOx burners to the SNCR process is $14,900/ton reduced. We find the average and incremental cost effectiveness of the SNCR and low NOx burners are not cost effective.

Ecology disagrees with Lafarge's conclusion that the mid-kiln firing with whole tires is not technically feasible due to a lack of a long term tire supply. We see used tires being produced for many years into the future. According to the Department of Ecology's publication Solid Waste in Washington, Fifteenth Annual Status Report[19], there are approximately 5 million waste vehicle tires produced in Washington each year and about 26% of those tires are not re-used in any way, but are disposed of in landfills. This Ecology report indicates that over 22 thousand tons of used tires are disposed of in landfills each year. According to the State of Texas[20], tires have a heat content of 14,000 Btu/lb and a sulfur content equivalent to the coal commonly used in Texas kilns. The steel in the tires makes a beneficial contribution to the iron oxide component of the finished cement.

With 22,000 tons of tires per year being disposed of in landfills in Washington, we believe that there is an adequate supply of tires for the foreseeable future. We have determined that the use of mid-kiln firing with whole tires is technically feasible.

While the heat content of tires makes it an attractive fuel source, industrial operations in Washington that have tried using tires as part of their fuel find significant handling and operational difficulties with their use. The steel component has proven to be a major ash handling issue for these facilities along with the increased particulate emissions due to the filler compounds (such as zinc oxide) in the tires.

Lafarge has already installed the equipment necessary to feed whole tires to their kiln. This installation was costly to the plant and full use of that capability has not yet been realized or permitted. We believe that since the cost of the modifications to allow mid-kiln firing of whole

[17] Based on a 7% interest rate and a 20 year lifetime for the emission control installed
[18] Based on a 7% interest rate and a 20 year lifetime for the emission control installed
[19] Ecology Publication 06-07-024, December 2006.
[20] Texas Cement Kiln Report (FINAL – 7/14/2006), page 4-39

tires has already been completed, the use of this technique instead of SNCR would result in reduced annual costs. We would anticipate the annual cost would be reduced to the costs necessary to purchase, store and feed whole used and discarded tires to the existing mid-kiln firing apparatus. While not evaluated in detail, we are if the opinion that implementation of mid-kiln firing of whole tires should be even more cost effective than the use of SNCR since most of the physical equipment is already in place at the plant.

Ecology considers the use of SNCR or mid-kiln firing of whole tires to be equivalent NOx control techniques for the Lafarge, wet process cement kiln. Both techniques are anticipated to provide a 40% reduction in NOx emissions.

Ecology determines that BART for NOx control at the Lafarge cement kiln is the use of SNCR or mid-kiln firing of whole tires. The emission limitation reflecting BART is provided in Table 4-1 below.

4.2.3 PM/PM10 Control

Ecology agrees with Lafarge's analysis that the existing ESPs provide a BART level of particulate control. The BART emission limitations for these ESPs is contained in Regulation 1, Section 9.09 (in effect on June 30, 2008) and Order of Approval Number 5627 of the Puget Sound Clean Air Agency. The emission limitation reflecting BART is provided in Table 4-1 below.

4.3 All other PM10 Sources at the plant

Ecology agrees with Lafarge's analysis that the existing ESPs provide a BART level of particulate control. The BART emission limitations for these ESPs is contained in Air Operating Permit Number 14046, issued to the Lafarge North America, Seattle Plant, on May 15, 2004 and modified July 28, 2004 by the Puget Sound Clean Air Agency. The emission limitation reflecting BART is provided in Table 4-1 below.

Table 4-1 Ecology's Determination of the Emission Controls That Constitute BART:

	BART control technology	Emission limitation
Clinker cooling		
PM/PM10/PM2.5	Existing baghouses	0.025 g/dscf for the Primary baghouse 0.005 g/dscf for Backup baghouse
Rotary kiln		
PM/PM10/PM2.5	Existing electrostatic precipitators	0.05 g/dscf
NOx	SNCR or Mid-kiln firing of whole tires	9.06 ton per day, annual average Not to exceed 11.48 ton/day
SO_2	Duct sorbent injection with lime plus currently permitted fuels and the cement	2.76 ton/day, annual average

	BART control technology	Emission limitation
	kiln process	Not to exceed 4.31 ton/day Not to exceed, 1000 ppmdv, one hour average
All other PM10 Sources at plant		
	Existing baghouses	0.005 g/dscf

APPENDICES

Appendix A

Principle References Used

RTP Environmental Associates, **PROPOSED BEST AVAILABLE RETROFIT TECHNOLOGY (BART) FOR THE LAFARGE PLANT IN SEATTLE WASHINGTON,** December 2007, amended by letters of March 11, 2008 and June 5, 2008

E-mail communication, Travis Weide, Lafarge-Seattle to Alan Newman, Ecology, April, 8, 2008, and June 5, 2008

ERG, Inc., **ASSESSMENT OF NOx EMISSIONS REDUCTION STRATEGIES FOR CEMENT KILNS - ELLIS COUNTY FINAL REPORT**, July 14, 2006, ERG No. 0195.00.002, TECQ Contract No. 582-04-65589, Work Order No. 05-06

Letter to David Shanbacher, Chief Engineer, Texas Commission on Environmental Quality, from Albert R. Axe, Jr, on behalf of the Portland Cement Association, commenting on report "**NOx Emission Reductions from Ellis County Cement Kilns**", June, 9, 2006. Includes report **The Experience of SCR at Solnhofen and its Applicability to US Cement Plants.** Robert J. Schreiber, Jr. P.E., Christa O. Russell, Schreiber Yonley & Associates, June 6, 2006

Portland Cement Association, **Comments on the Final Report "Assessment of NOx Emissions Reduction Strategies for Cement Kilns – Ellis County",** November 20, 2006

Raytheon Engineers and Constructors, Inc. and Easter Research Group, Inc., **COAL UTILITY ENVIRONMENTAL COST (CUECost) WORKBOOK USERS MANUAL** and Excel Spreadsheet, Version 1.0, 1998, Provided by EPA.

CEMBUREAU, **"BEST AVAILABLE TECHNIQUES" FOR THE CEMENT INDUSTRY**, 1999

European commission, **Institute for Prospective Technological Studies, Integrated Pollution Prevention and Control, REFERENCE DOCUMENT ON THE BEST AVAILABLE TECHNIQUES IN THE CEMENT AND LIME MANUFACTURING INDUSTRIES**, Draft September 2007

Trinity Consultants, **FIVE FACTOR BART ANALYSIS FOR ASH GROVE CEMENT, Montana City, MT**, June 2007, plus EPA comment letter of January 9, 2008 to Joe Scheeler, Ash Grove Cement Company from Callie A. Videtich, Director, Air and Radiation Program

Bison Engineering, Inc. **BEST AVAILABLE RETROFIT TECHNOLOGY ANALYSIS, Holcim (US) Inc, Three Forks, MT**, July 2007, plus EPA comment letter of January 9, 2008 to

Ned Pettit, Environmental Manager, Holcim, Inc. from Callie A. Videtich, Director, Air and Radiation Program

A. A. Linero, P.E., What's Up With Cement Plant Permitting?, Florida Department of Environmental Protection, 2002

Nicholas Confuorto, Belco Technologies Corp & Jeffrey Sexton, Marathon Petroleum Company LL, **WET SCRUBBING BASED NOX CONTROL USING LOTOX™ TECHNOLOGY - FIRST COMMERCIAL FCC START-UP EXPERIENCE. Paper given at NPRA Environmental Conference, Austin, Texas,** 24, 25 September 2007

Air and Waste Management Association, Editors, Anthony Buonicore and Wayne Davis, **AIR POLLUTION ENGINEERING MANUAL**, Von Nostrand Reinhold, 1992

Sargent & Lundy, **DRY FLUE GAS DESULFURIZATION TECHNOLOGY EVALUATION**, Prepared for National Lime Association, Project Number 11311-000, September, 2002

Appendix B

Summary of Ecology's Cost Analysis

Equipment life		20	years
Capital cost recovery period		7	%
CR factor		0.0944	

	Uncontrolled tpy	% reduction	tons reduced'	Capital cost (CUECost)	Annualized capital cost	Annual O&M Cost	Total annual cost	$/ton	Source of cost information
mid-kiln firing	2172.5	0.5	1086.25	0			$ -	$ -	
SNCR	2172.5	0.4	869	$ 1,499,410	$ 141,544	$ 1,082,997	$ 1,224,541	$ 1,409	CUECost
SNCR+LNB/IDF	2172.5	0.55	1194.9	$ 16,499,410	$ 1,557,544	$ 5,938,737	$ 7,496,281	$ 6,274	CUECost + applicant
LNB/IDF	2172.5	0.15	325.9	$ 15, 000,000	$ 1,416,000	$ 4,855,740	$ 6,271,740	$ 19,246	Applicant, from 2000 Cement ACT
LSFO	570	0.9	513	$ 64,139,934	$ 6,054,810	$ 4,875,339	$ 10,930,149	$ 21,306	CUECost
LSD	570	0.7	399	$ 42,313,879	$ 3,994,430	$ 3,135,824	$ 7,130,254	$ 17,870	CUECost
Dry Sorbent Injection	570	0.275	156.75	$ 6,090,000	$ 574,896	$ 541,675	$ 1,116,571	$ 7,123	Applicant supplied capital costs information, April, 2008. Annual costs derived by ARN utilizing CUECost analysis factors and accounting for already existing equipment and staff. Operating staff reduced from CUECost to 0.5 FTE/shift from 1 FTE/shift based on observation of operating control systems.

Appendix C

Derivation of BART Emission Limitations for NOx and SO_2

Ecology has evaluated the BART emission limitations for NOx and SO_2 and determined that the limit is to be a single ton per day day, not to exceed value. Lafarge proposed that the emission limitations be ton per day 30 day rolling averages. Both of these proposed emission limitations are in contrast to the more common process rate based limitation of lb/ton of clinker applied to cement kiln emissions in BACT and other new source review permitting.

The rationale for Ecology to utilize a maximum day, not to exceed limitation considers the following:

- The baseline emission rate used by Lafarge and Ecology for control system effectiveness and visibility modeling was the 24 hour maximum rate for NOx and SO_2 that during a specific 3 year period.
- The emission reduction analyses used by Lafarge applied the control effectiveness of the various control options impact on the 24 hour maximum rates in the specific 3 years period.
- Lafarge proposed the 24 hour maximum ton per day emission rate after control (reducing the plant's emissions by 25% for SO_2 and 40% for NOx) as their proposed 30 day average limitation.
- If the 30 day average value were met year around, the resulting annual emissions would be higher than the plant's current annual emission rate, an inappropriate result.
- Since the control equipment will not be installed and start operation for several years after the BART determination is issued, the local permitting authority will be able to reflect the capabilities of the controls within its approval to install and operate the BART required control equipment.
- The company could choose to implement one of 2 NOx controls. Each control has specific and different process monitoring requirements best reflected in a local permitting authority approval to install and construct.
- The local permitting authority has the ability to establish appropriate lb/ton of clinker, 30 day (or shorter) average emission limits as part of their permitting action to approve Lafarge's installation and use of the BART emission controls.
- Ecology by establishing a maximum tons per day emission rate plus the local permitting authority establishing an appropriate limitation to assure the control technology is operated properly will in combination, establish a series of appropriate emission limitations on the facility.

As a result, Ecology has determined that for the emission limitation that defines BART for Lafarge's SO_2 and NOx emissions is to use their proposal as establishing a daily maximum rate. This maximum daily rate is the maximum day emission rate used for modeling (the baseline emission rate) multiplied by the control effectiveness. The resulting NOx and SO_2 emission rates are depicted in Table 4-1.